Environmental Health Engineering and Management Journal 2022, 9(1), 75-83
http://ehemj.com
doi 10.34172/EHEM.2022.09

Environmental Health Engineering and Management Journal

Original Article

Environmental Health Engineering and Management

Open Access Publish Free

Applying analytic hierarchy process method for quantitative assessment of environmental health factors in hospitals using existing quality checklists: A modeling and field study

Reza Nemati[1*], Fatemeh Fathi[1], Mohammad Amin Ghorbanpour[2]

[1]Student Research Committee, Saveh University of Medical Sciences, Saveh, Iran
[2]Department of Environmental Health Engineering, Health Deputy, Saveh University of Medical Sciences, Saveh, Iran

Abstract

Background: Since there are various factors with different importance that determine environmental health status of hospitals, judging and prioritizing the required corrective actions using the current qualitative checklists is problematic and, in some cases, deceptive. This study explored a decision support model for hospital environmental health status to establish a quantitative method based on the analytic hierarchy process (AHP) using the Iranian National Hospital Evaluation checklist.

Methods: The research was done in two separate phases; first, score weighting of the criteria and sub-criteria (questions) in the existing checklist using the AHP, and second, a field study of the environmental health status of the hospitals using a weighted checklist. In the field study, the environmental health status of the studied hospitals was sored using checklist questions, and finally, the final scores of each criterion were calculated and aggregated to determine the environmental health status of the studied hospitals.

Results: Among the main criteria, the infection control criteria with a final weight coefficient of 0.5371, was the most important factor, and the building criteria with a final weight coefficient of 0.0341 had the lowest weight in determining the environmental health status of the hospitals. On average, the environmental health status of the studied hospitals was about 76%, which are in a moderate status.

Conclusion: The environmental health status of Iran's hospitals has typically been evaluated only qualitatively and without considering their weight importance. The present study provides a flexible method for quantitative assessment of the environmental health status of hospitals.

Keywords: Analytic hierarchy process, Environmental health, Health services, Hospitals, Infection control

Citation: Nemati R, Fathi F, Ghorbanpour MA. Applying analytic hierarchy process method for quantitative assessment of environmental health factors in hospitals using existing quality checklists: A modeling and field study. Environmental Health Engineering and Management Journal 2022; 9(1): 75-83. doi: 10.34172/EHEM.2022.09.

Article History:
Received: 17 May 2021
Accepted: 16 October 2021
ePublished: 29 January 2022

***Correspondence to:**
Reza Nemati,
Email: Reza.Nemati84@gmail.com

Introduction

Lack of attention to the direct relationship between the environmental health status of hospitals and the prevalence of healthcare-associated infections is a main issue that has been always a challenge for hospitals (1-3). The attention to environmental health to control hospital infections emerged as a coherent program in America in the late 1950s for controlling staphylococcal infections and it significantly affected the results of operations and resulted in the reduction of the transmission of nosocomial infections from the inside to outside and vice versa (4-7). Inattention to environmental health standards of hospitals leads to higher mortality due to nosocomial infections (as the sixth leading cause of death before AIDS and traffic accidents), prolongation of hospital stays for patients, and ultimately, an increase inpatient and hospital costs (1, 6, 8-10). In controlling the environmental health of hospitals, the main supervised issues are the building status of hospitals, water used in different wards of hospitals, wastewater and the way of its treatment and disposal, waste produced in different wards and the way of its management, foods (including the supply, storage, preparation, and distribution), infection control (principles of washing, cleaning, and disinfection), general hygiene principles, and manpower. Any negligence, ignorance, and non-observance of hygiene principles cause irreparable damages (5, 9, 11). As mentioned, the observance of environmental health rules and standards is an important factor that can break the chain of transmission of these infections and prevent them (12-14) and any negligence in this field leads to irreparable damages (15).

Fortunately, this issue is being considered in hospitals, and environmental health assessments are being performed, and corrective measures are being taken based on the results. Given the multiplicity of effective factors in determining the environmental health status of hospitals and their different weight importance, evaluating the health status of hospitals based on prioritizing and influencing the weight importance of factors is a major need of hospital management. Most evaluations are based on separate qualitative assessments of factors, without considering their weight importance (16, 17). Based on the results of this type of evaluation, it is only possible to determine strengths and weaknesses, and it is not possible to determine the general status of hospitals, and also, to compare the general status of the hospital with other hospitals.

An important method to consider the weight importance of factors is the use of an analytic hierarchy process (AHP) as the basis for the criteria prioritization and determining the weight criteria. There are few studies on determining the environmental health status of hospitals using the AHP. The innovation of the present research was the use of the AHP and the conversion of the existing qualitative approach to a quantitative method based on prioritizing and expert opinions. After determining the weights of criteria (main and sub-criteria), four hospitals in Saveh and Mamuniyeh were assessed in terms of environmental health criteria using the AHP. Since the managerial strategies require comprehensive and specific information to improve the environmental health status of the hospitals, it is necessary to quantitatively determine the strengths and weaknesses of environmental health programs of hospitals and provide useful information to improve the hospital status.

Materials and Methods

This study establishes a quantitative method for determining the environmental health status of hospitals using the current qualitative checklist of the hospital prepared by the Ministry of Health and Medical Education of Iran. This research had two separate phases; first, score weighting of the criteria and sub-criteria (questions) in the existing checklist using the AHP, and second, case application of the evidential reasoning based AHP approach of the environmental health status of the hospitals using a weighted checklist (obtained in the first phase).

The first phase: The hierarchical process study

In this study, data were collected using the environmental health checklist of the National Evaluation Program of Public Hospitals. This checklist has been prepared by the Ministry of Health and Medical Education and its content validity has been confirmed. The content validity was determined using the content validity index (CVI) and content validity ratio (CVR). The CVI and CVR were calculated based on the Lawshe (18) and Waltz & Bausell (19) methods. Also, the reliability was determined using Cronbach's alpha coefficient (20). Table 1 lists the main criteria that are used for pairwise comparison of this checklist. As presented in this table, the checklist consists of 6 main criteria and a total of 69 sub-criteria (questions). The experts performed the pairwise comparison of criteria and sub-criteria in the checklist in the AHP and their mean opinions were considered.

In Table 2, the first phase steps are summarized. On this basis, the steps of the present research included receiving a checklist for determining the environmental health status of the hospitals, pairwise comparison of each main criterion and sub-criteria in the checklists with each other, and weighting them based on scientific texts and experts' views about this field, the calculation of scores, and ranking each criterion in the hospitals. The criteria were scored using the AHP and the matrix method of pairwise comparisons. In this process, the status of the general criterion could be determined by dividing it into separate measures and investigating the weight importance of the small criteria in the pairwise comparison and their mathematical summing up.

In this process, determining the importance of criteria started from the main criteria and scoring each one was completed by extending them to minor options (sub-criteria). The weights of the main criteria were determined according to Table 3 (21, 22), and a simple pairwise comparison was used to determine the weights of sub-criteria. The matrix pairwise comparison for the main criteria was similar to Eq. (1) (23).

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

Where n criteria for comparison (C_1, C_2,…, C_n) and a relative score of C_i (according to Table 1) is a_{ij} in comparison with C_j, the score of C_{ji} is reciprocal and equal to $1/a_{ij}$ (fraction inverse of the opposite score). Therefore, a square matrix like the matrix of Eq. (1) is formed.

The above-mentioned matrix (matrix A) is a square matrix with a size of n × n, in which n is the number

Table 1. The main criteria used in the questionnaire and the number of sub-criteria

Main Criterion	Number of Sub-criteria
Waste management	16
Water and wastewater	6
General factors and personnel	12
Kitchen factors	18
Building health factors	8
Infection control	9
Sum	69

Table 2. Summary of the first phase steps

Step	Statement
1	Perusing the Iranian National Hospital Evaluation checklist in determining the environmental health status and extraction of usable wards in the studied hospitals.
2	Pairwise comparison of the main criteria and filling the scoring matrix to determine the final weight of each of the main criteria by experts.
3	Single pairwise comparison of sub-criteria (each main criteria questions) and determining the weight of each sub-criterion in the main criterion by experts.
4	Calculating the final importance coefficient of the main criteria and sub-criteria.

of compared criteria. After obtaining the pairwise comparison matrix, it is needed to measure the weight of each criterion. In the present study, the "aggregation of individual priority weights" was used to take into account the experts' opinions due to the different scoring. In this method, the geometric mean score of each criterion was used.

In the analytical hierarchy process, it is needed to evaluate the consistency of judgments to ensure the quality of the final decision. The consistency index must be determined to determine the degree of consistency of the judgments made by the decision-maker. It is calculated using Eq. (2).

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (2)$$

Where λ_{max} is the maximum eigenvalue of matrix A, and n is the length of the matrix (number of rows or columns). λ_{max} is always greater than or equal to n. According to Eq. (2), the consistency index depends directly on dimensions of the comparative matrix (A). The consistency ratio index is applicable to solve this problem (24). This index is calculated using Eq. (3) (23).

$$CR = \frac{CI}{RCI} \quad (3)$$

Where *CR* is the consistency ratio index, *CI* is the consistency index calculated for the square matrix, and *RCI* is a random consistency index. The values of RCI are calculated for square matrices in which the numbers are random. The values of the random consistency index for n-dimension matrices are shown Table 4.

The acceptable range of consistency in any system depends on the decision-maker, but the relative consistency index should be generally less than 10%, otherwise, the judgment should be revised.

The second phase: Case application of the AHP approach

In this study, the use of the proposed AHP approach is detailed in the following. Three hospitals of Saveh and one hospital of Mamuniyeh located in Saveh and Zarandieh counties (counties of Markazi province) were investigated in terms of environmental health status. Figure 1 shows the geographical location of Markazi province in Iran (a), the geographical locations of Saveh and Zarandieh counties in Markazi province (b), and the geographical locations of Saveh and Mamuniyeh in the province (c), which are the capital of Saveh and Zarandieh, respectively. It also shows the locations of three hospitals in Saveh (d) and one hospital in Mamuniyeh (e).

Table 3. Definitive importance scale

Importance Value	Description
1	Similar importance
3	Ordinary importance
5	Strong importance
7	So strong importance
9	Crucial importance
2, 4, 6, 8	Compromise values between those above

Table 4. The random consistency index for n-dimension matrices

n	RCI
3	0.525
4	0.882
5	1.115
6	1.252
7	1.341

RCI, random consistency index

According to the latest census (2016), Saveh county has a population of about 285 000 and Zarandieh county has a population of about 64 000. Accordingly, these counties have the highest population growth rates in Markazi province. In this study, three hospitals in Saveh city (Figure 1 (d) and one hospital in Mamuniyeh city (a) were studied.

In Saveh city, Shahid Modarres Teaching hospital (with 17 Shahrivar hospital) with 247 beds is under the coverage of the Faculty of Medical Sciences, Shahid Chamran hospital as a teaching public hospital with 124 beds is under the coverage of the Social Security Organization, and Hazrat Fatemeh hospital a public non-teaching hospital with 96 beds is under the coverage of the private organization. Also, in Mamuniyeh city, Imam Reza hospital with 32 beds is under the coverage of the Faculty of Medical Sciences.

According to the standard checklist, the answer to each question is in 3 options (No, Somewhat, Yes). In this study, the options are scored from 0 to 100 (No: 0-20, Somewhat: 21-60, Yes: 61-100), according to interviews, attending hospital wards, and observation of documents.

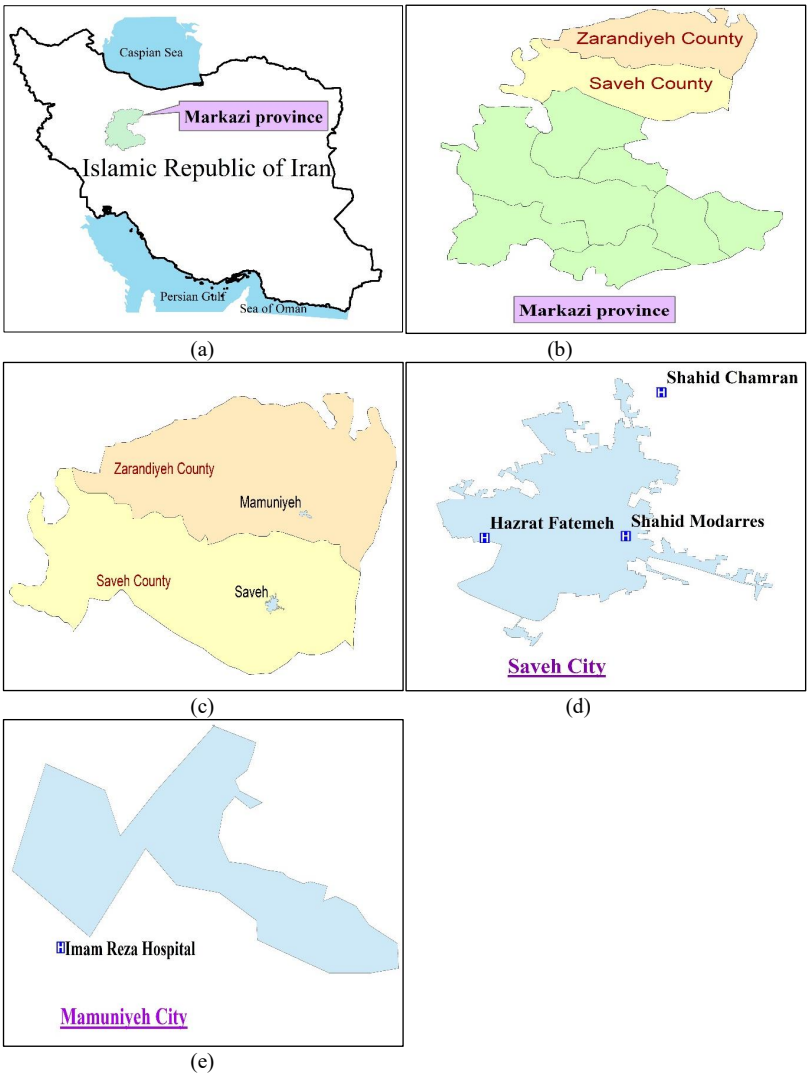

Figure 1. (a) Geographical location of Markazi province in Iran, (b) Geographical location of Saveh and Zarandieh counties in Markazi province, (c) Location of Saveh and Mamuniyeh cities as the capitals of Saveh and Zarandieh counties, respectively,) d) Location of Saveh hospitals (Shahid Modares Hospital, Hazrat Fatemeh Hospital, Hospital, Shahid Chamran Hospital), and)e) Location of Imam Reza Hospital in Mamuniyeh.

Then, according to the determined scores, the status of the hospitals in the main and total criteria were determined as unfavorable status (scores below 60), the moderate status (scores between 60 and 80), and the favorable status (scores above 80).

Results

As mentioned, to check the reliability, Cronbach's alpha (20) was calculated and it was reported to be 0.81, which indicates a good degree of reliability. According to the Lawshe table, for 8 experts, a CVR value higher than 0.75 is needed (18). The calculated CVR was 0.865, which it was considered as favorable. Also, Waltz and Bausell (19) method was used to evaluate the CVI. The CVI calculated for the whole checklist was 0.872, indicating that it satisfied the minimum value of 0.83 for 8 experts (25).

After checking validity and reliability of the checklist and forming a hierarchical table, a pairwise comparison was conducted and relative weights of the criteria were calculated using AHP. The pairwise comparison matrix of each group was formed using the professors' and experts' views and the weight factor of each criterion was calculated. For the main criteria, the inconsistency rate was used to measure the matrix and hierarchy criteria matrix. Since it was less than 0.1 (0.087), it was acceptable and there was no need for revision in the judgment. Figure 2 shows the final factors obtained for the main indices to determine the environmental health status of the hospitals. Among the main criteria, the infection control criterion with a final weight coefficient of 0.5371 was the most important factor and the building criterion with a final weight coefficient of 0.0341 had the lowest weight in determining the environmental health status of hospitals.

As mentioned, the main criteria of the present study had sub-criteria. For each criterion, the pairwise comparison of sub-criteria was performed using the experts' views, and the importance factor of each sub-criterion was calculated separately.

In the second phase, the sub-criteria (questions of each criterion) were scored according to the prevailing

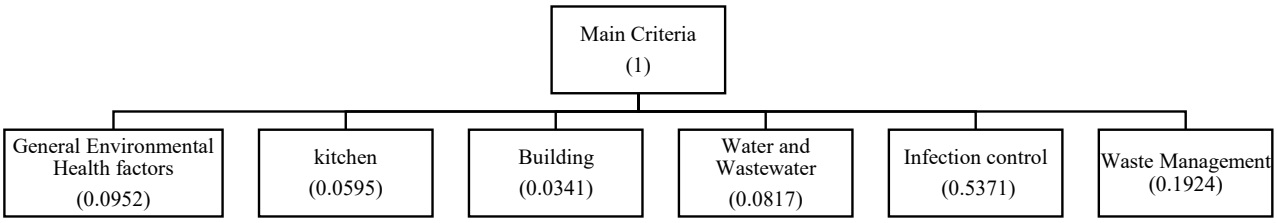

Figure 2. Final factors obtained for the main indicators to determine the health status of the hospital environment.

conditions and the experts' views with the field presence of experts and environmental health experts of each hospital. By multiplying the score of each sub-criterion by the importance factor of the same sub-criterion (calculated in the first phase), the final score of each sub-criterion in determining the environmental health status was calculated. By aggregating the scores of the sub-criteria of each criterion, the general status of each hospital in the relevant criterion was determined. By multiplying the score of each criterion by the weight importance factor of the same criterion (calculated in the first phase) and aggregating the obtained numbers, the general status of each hospital in terms of environmental health was determined. Figure 3 shows the environmental health status of Shahid Modarres Hospital of Saveh in each main criterion in a multiple of 100. As shown in this figure, the water and wastewater criterion has the lowest score of about 40% than other criteria. Also, the hospital has performed better in infection control with a score of 75% compared to other criteria. By taking into account the final factors of each criterion, the overall average of the hospital in all criteria is about 68%.

Figure 4 shows a comparative diagram of environmental health indices of Hazrat Fatemeh hospital in Saveh. According to the figure, this hospital has been relatively successful in the waste management criterion (with a score of 90%). Furthermore, the hospital was scored lower in the water and wastewater criterion compared to other indices. The final score of this hospital was 75% in all factors by applying the multiples of the final factor criteria.

Figure 5 shows a comparative diagram of different environmental health factors in Shahid Chamran hospital in Saveh. According to the figure, the hospital is in a good status to a large extent in terms of water and wastewater and infection control indices. The waste management criterion of the hospital has a lower score than other indices. The final score of the hospital is about 87% in all indices by applying the multiples of the main criteria.

Figure 6 shows a comparative diagram of the main environmental health criteria at Imam Reza Zarandieh hospital. According to the figure, the hospital is in a very good status to a large extent in terms of general indices, manpower, and infection control. The building health criteria of the hospital has a lower score than the other criteria. The final score of the hospital is about 74% in all factors by applying the multiples of the main criteria.

According to the above figures, the hospitals of Saveh and Zarandieh are not in a good status in the water and wastewater criteria compared to the other criteria and are relatively scored lower in this section.

Table 5 presents the status of each hospital qualitatively based on the results obtained in each main criterion of environmental health (criteria). This table is created by summing up the weighted scores of each hospital in all criteria. After finalizing the scores, the general status of hospitals in the main and total criteria (scores below 60 = Unfavorable, scores between 60 and 80 = Moderate, and scores above 80 = Favorable) were determined. As presented in the table, the water and wastewater criteria

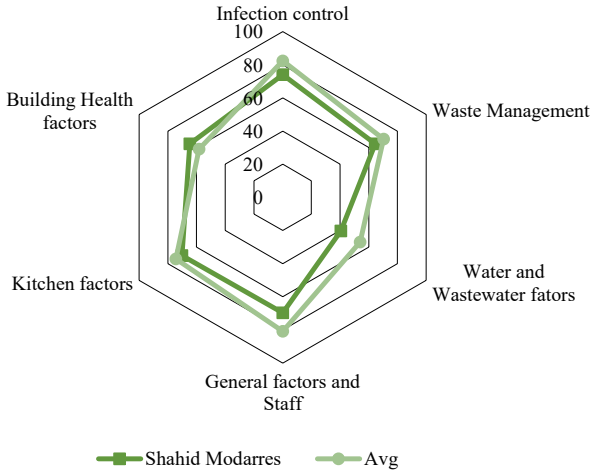

Figure 3. Score diagram of the main environmental health criteria (%) in Shahid Modarres hospital compared with the average scores of the studied hospitals.

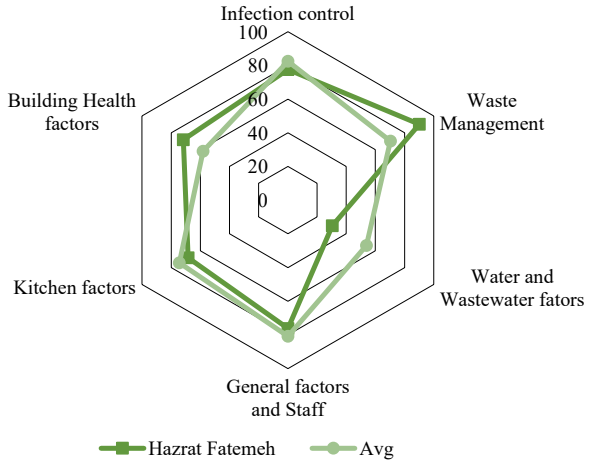

Figure 4. Score diagram of the main environmental health criteria (%) in Hazrat Fatemeh hospital compared with the average scores of the studied hospitals.

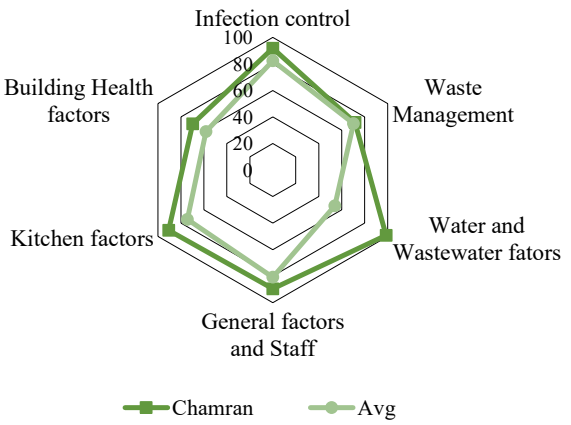

Figure 5. Score diagram of the main environmental health criteria (%) in Shahid Chamran hospital compared with the average scores of the studied hospitals.

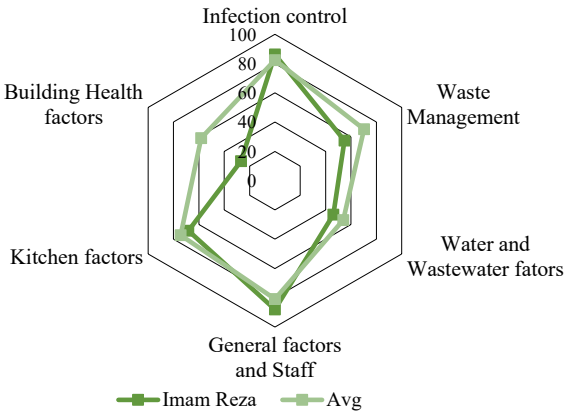

Figure 6. Score diagram of the main environmental health criteria (%) in Imam Reza hospital compared with the average scores of the studied hospitals.

were unfavorable in three of the four hospitals.

Discussion

In most pervious researches, in order to quantify the environmental health status of hospitals, the weight of the criteria in relation to each other has been ignored and all the criteria have been considered with the same importance. The important needs of hospital management include determining the environmental health status of hospitals and the difference in the importance of each factor and evaluating the environmental health status of hospitals based on the priorities and weights of the factors (26). Feasibility and planning studies done correctly cause competence in choosing the correct actions which could increase the quality of health care delivery and reduce the rate of dissatisfaction and complaints as well as costs imposed by the unhealthy environment (27). Although studies on determining the health status of hospitals based on the prioritization of criteria and their quantitative evaluation are very limited, but many studies have provided methods for evaluating such multi-criteria indicators. For instance, Akhanova et al used a stepwise assessment procedure for the weight allocation of building sustainability assessment system (28). They proposed a framework for building sustainability assessment in Kazakhstan. This framework was compared with other international systems for validation. According to the findings of this research, there are similarities and variances in terms of categories in the proposed framework and international green building rating systems. An effective method in determining the AHP is the prioritization of criteria and determining the criteria weights (29). Karimi et al proposed a fully high flexibility fuzzy best-worst method without need to do all the possible pairwise comparisons (30). According to this study, only reference comparisons would be done. The proposed method in the present study also has this suitable feature. In the study of Karimi et al, the reference comparison includes of pairwise comparison between the most important criterion with other criteria, and a pairwise comparison between the least important criterion with other criteria. Also, Zhu et al developed an evaluation model for general assessment (economic, social, and environmental) of different toilet technologies based on the specialized questionnaires and the application of the AHP method. In this study, 7 main criteria and 31 sub-criteria were

Table 5. Status of Saveh and Mamuniyeh hospitals in terms of the environmental health indicators

Hospital		Infection Control	Building Health Factors	Kitchen Health Factors	General Factors and Personnel	Water and Wastewater Factors	Waste Management	Final Status
Shahid Modarres	Score	74.00	64.72	70.15	69.68	40.48	64.49	68.47
	Status	Moderate	Moderate	Moderate	Moderate	Unfavorable	Moderate	Moderate
Hazrat Fatemeh	Score	77.56	71.67	68.42	76.15	30.48	90.15	75.25
	Status	Moderate	Moderate	Moderate	Moderate	Unfavorable	Favorable	Moderate
Shahid Chamran	Score	91.78	69.72	90.70	89.49	98.57	71.62	87.42
	Status	Favorable	Moderate	Favorable	Favorable	Favorable	Moderate	Favorable
Imam Reza	Score	86.22	26.67	68.25	87.95	46.19	54.85	73.98
	Status	Favorable	Unfavorable	Favorable	Moderate	Unfavorable	Unfavorable	Moderate
Average	Score	70.28	53.93	80.82	74.38	58.19	82.39	76.28
	Status	Moderate	Unfavorable	Favorable	Moderate	Unfavorable	Favorable	Moderate

examined. By appling the presented method, decision makers can score both qualitatively and quantitatively to assess the situation (31). Also, the results of this study showed that the use of AHP method and its modified is a reasonable way to control the impact of several effective factors with different importance on a multi-parameter index. Also, a comparative study in the the United Arab Emirates aimed to apply a quantitative framework for evaluating the environmental performance of healthcare suppliers (32). According to this study, the application of the AHP guarantees a systematic evaluation of health care provider's competence in terms of environmental standards. Similarly, in the present study, the AHP method reduced the number of different-layer indicators comparisons (criteria and sub-criteria), and also, the difficulty of voting by experts, resulting in inaccurate results.

Handfield et al used the AHP model as a decision support tool for decision makers to evaluate environmental dimensions in the industry applications (33). They proposed how to use AHP to evaluate the relative importance of different environmental criteria and how to evaluate the relative importance of several suppliers along with these criteria. Firstly, they separately ranked pairwise criterion against the other criteria. The rankings were accomplished using 1 to 9 score range, where 1 shows that the two criteria are equally important and 9 shows that the criterion is extremely more important. These rankings were used to determine the weights assigned to each criterion. In this study, three case studies were conducted to validate the advantages and disadvantages of using AHP in this method (33). In general, different methods based on the AHP have been used in various aspects of environmental issues as a decision making support tool (22, 32, 34). This study, similarly, suggested an AHP method for quantitative assessment of environmental health factors in hospitals. The innovation of the present study is the use of AHP and conversion of the existing qualitative method to a quantitative method based on prioritization and experts' views.

Comparison of the weight factor obtained for the main criteria showed that the infection control criterion was the most important criterion and the construction criterion had the lowest weight in determining the environmental health status of hospitals (12, 27).

According to the results of this study, the three hospitals were in a moderate status and one hospital in an optimal status in terms of environmental health indices. In the studied hospitals, waste sorting was generally performed acceptably. In the waste management, the biggest problem was the placement of waste with the smallest volume in large plastic bags and the lack of color labeling and coding.

In the field of hospital wastewater, it is predicted that providing a solution for managing the sanitary disposal of wastewater and compliance of existing waste of the treatment plant with the standards announced by the Environmental Protection Agency (EPA) will play a useful and effective role in improving water and wastewater status of hospitals. In terms of generalities and human resources, paying attention to the emphasis of hospitals on the personnel's health cards and passing public health training courses and periodic vaccination of staff, which prevent staff from getting diseases due to working in the hospitals, can improve the criterion. In the field of the kitchen and food hygiene criterion, more monitoring of having a health card and public health education certificate for staff working in the kitchens, daily recording of the temperatures of refrigerators and freezers for storing foods in the kitchen and monitoring them improve this criterion. Furthermore, the implementation of the health system development plan improves the environment and building health criterion.

Different problems have been reported in studies on the environmental health status of different hospitals in Iran. A study conducted by Jonidi Jafari et al indicated that hospitals of Karaj sorted the infectious and non-infectious waste in the origin in a sanitary manner, and the greatest problem with the waste management was related to the temporary waste sorting and their disposal systems (35). According to the results, the water and wastewater criteria of hospitals were very different to reach the standard. Most of the hospitals in the county had generalities and manpower lower than the standard due to the lack of health committees, staff negligence in occupational fields, and non-observance of health principles by the clients. In the field of infection control, the hospitals were in a good status with the lowest percentage of score difference with the standard limit (35). In a study by Azghandi et al in Sabzevar hospitals, the sanitary collection and disposal of hospital wastewater were moderate and poor. Based on the results of the study, Sabzevar hospitals were in a poor status in terms of building criterion but were in an acceptable status in terms of infection control (4). A study in Kerman in 2010 also indicated that 25% of hospitals were in a good status in terms of hospital indices and a large percentage of teaching hospitals were not in a favorable status; hence, more efforts are recommended to improve their status (12). In a study in Qom and Fars, hospitals were in a relatively favorable status in terms of compliance with environmental health standards (6, 24). As mentioned, in the present study compared to other researches (3, 4, 6, 12,35), the final score of each hospital was calculated by considering the importance of the main criteria. In a recent study by Romero and Carnero, a similar method was used to assess the environmental criteria in health care organizations. In this study, a final score of 62.86 out of 100 was reported, which is comparable to the results of the present study (68%).

In Saveh, the staff was fully acquainted with methods of prevention and control of nosocomial infections due to the

holding of practical classes and necessary regular training to individuals. Moreover, follow-up and measures, which were seriously planned by the Ministry of Health and Medical Education to prevent nosocomial infections, and the sensitivity of environmental health experts in hospitals, and the high expectations of hospitalized people and attendants, and the use of disposable gloves in facing with patients were effective in improving the current status. The present study shows that the studied hospitals are in the middle level of the standard in terms of environmental health and construction.

Conclusion

The present study provides a flexible method for quantitative assessment of the environmental health status of hospitals. According to this method, each factor is assigned a role in determining the environmental health status of the hospitals based on its importance. Therefore, a more accurate judgment can be made about the environmental health status of hospitals. More importantly, the assessment of each environmental health criterion can be utilized by hospital management team. Also, a better comparison between the status of different hospitals can be made. According to the results, the infection control criterion is the most important factor and the building criterion has the lesser weight in determining the environmental health status of hospitals. The field study results indicated that the studied hospitals were generally in a better status in terms of environmental health standards compared to other hospitals in Iran. The AHP must assess the consistency of judgments to ensure the quality of final decisions.

The environmental health status of Iran's hospitals has not been taken into consideration despite its importance and necessity in carrying out and advancing the mission of hospitals; hence, basic measures should be taken to improve it. The authorities are suggested to perform more follow-up of water and sewage criterion and building hygiene to improve the quality of environmental health indices in Saveh hospitals and bring the indices to the desired level of health standards. It is also necessary to consider the waste management, kitchen hygiene, generalities, and infection control manpower indices. The results of the field study showed that three hospitals are in a moderate status and one hospital is in a favorable status in terms of environmental health indicators by considering the importance and prioritization of criteria.

Acknowledgements

This research received a specific grant from Student Research Committee of Saveh University of Medical Sciences, Saveh, Iran (Grant No 99-02-13).

Ethical issues

The study protocols were approved by the Ethics Committee of Saveh University of Medical Sciences, Saveh, Iran (Ethical code: IR.SAVEHUMS.RES>1399.017).

Conflict of interests

The authors declare that they have no conflict of interests.

Authors' contributions

All authors contributed and were involved in the problem suggestion, methods design, data collection, and manuscript approval.

References

1. Jenkins DR. Nosocomial infections and infection control. Medicine 2017; 45(10): 629-33. doi: 10.1016/j.mpmed.2017.07.005.
2. Barcelo D. An environmental and health perspective for COVID-19 outbreak: Meteorology and air quality influence, sewage epidemiology indicator, hospitals disinfection, drug therapies and recommendations. J Environ Chem Eng 2020; 8(4): 104006. doi: 10.1016/j.jece.2020.104006.
3. Unger S, Landis A. Assessing the environmental, human health, and economic impacts of reprocessed medical devices in a Phoenix hospital's supply chain. J Clean Prod 2016; 112: 1995-2003. doi: 10.1016/j.jclepro.2015.07.144.
4. Azghandi F, Molazem Alhoseini R, Khamirchi Ramezan A, Hoshmand R. The status of environmental hygiene indexes in Sabzevar educational hospitals: 2014. Beyhagh 2016; 21(36): 60-6. [In Persian].
5. Hosseinpoor S. Investigating status of environmental and structural health indicators among therapeutic and educational hospitals of Urmia, In 2016. Nurs Midwifery J 2017; 15(1): 58-66. [In Persian].
6. Salimi M, Arab M, Akbari F, Zeraati H, Farzianpoor F. A survey on the status of environmental health management in Qom province hospitals. Journal of School of Public Health and Institute of Public Health Research 2007; 5(3): 59-66. [In Persian].
7. Mohseni Band-pay A, Majlesi M, Tabrizi Azad M. Performance evaluation of non-incineration treatment facilities for disinfection of medical infectious and sharps wastes in educational hospitals of Shahid Beheshti University of Medical Sciences in 2013. Environmental Health Engineering and Management Journal 2015; 2(2): 93-7.
8. Ziasheikholeslami N, Razavian F, Vafaei K, Esmkhani S. Evaluation of the level of hand hygiene in intensive care unit personnel of Kamkar education, research and treatment center of Qom in 2014, Iran. Qom Univ Med Sci J 2016; 10(3): 64-9. [In Persian].
9. Liu JY, Dickter JK. Nosocomial infections: A history of hospital-acquired infections. Gastrointest Endosc Clin N Am 2020; 30(4): 637-52. doi: 10.1016/j.giec.2020.06.001.
10. Allen M, Hall L, Halton K, Graves N. Improving hospital environmental hygiene with the use of a targeted multi-modal bundle strategy. Infection Disease & Health 2018; 23(2): 107-13. doi: 10.1016/j.idh.2018.01.003.
11. Azizoglu F, Kose A, Gul H. Self-reported environmental health risks of nurses working in hospital surgical units. Int Nurs Rev 2019; 66(1): 87-93. doi: 10.1111/inr.12467.
12. Mehdipour Rabori M, Khalooei A, Nakhaei Amroudi N, Nourmoradi H. Compliance with Environmental Health

Standards in Educational Hospitals of Kerman University of Medical Sciences in 2009. J Health 2014; 5(2): 159-69. [In Persian].
13. Rostaminejad A, Mobaraki A, Zahmatkeshan N. Performance of the operating room personnel in following of the standards of infection control in the educational hospitals of Yasuj University of Medical Sciences in 2009. Armaghane Danesh 2011; 16(1): 90-9. [In Persian].
14. Malakootian M, Amiri Gharghani M. Investigation of type and density of bio-aerosols in air samples from educational hospital wards of Kerman City, 2014. Environmental Health Engineering and Management Journal 2016; 3(4): 197-202. doi: 10.15171/EHEM.2016.20.
15. Darvishpoor K, heshmati H, Rezaei Manesh M R, Mir hasani M. Prevalence of nosocomial infections and microbial causes in Torbat heydariyeh 9dey educational and clinical hospital in 2012 and 2013. Iran J Med Microbiol 2016; 10(1): 93-6. [In Persian].
16. Albert M, Lemdani M, Cuny D, Duriez P, Escutnaire J, Gueugniaud PY, et al. Analysis of out of hospital cardiac arrest and ozone pollution: a qualitative study. Environmental Health Engineering and Management Journal 2019; 6(4): 283-89. doi: 10.15171/EHEM.2019.32.
17. Yousefi Z, Avak Rostami M. Quantitative and qualitative characteristics of hospital waste in the city of Behshahr-2016. Environmental Health Engineering and Management Journal 2017; 4(1): 59-64. doi: 10.15171/EHEM.2017.09.
18. Lawshe CH. A quantitative approach to content validity. Personnel Psychology 1975; 28(4): 563-75. doi: 10.1111/j.1744-6570.1975.tb01393.x.
19. Waltz CF, Bausell B. Nursing research: Design statistics and computer analysis. Philadelphia: F.A. Davis Co; 1981.
20. Cronbach LJ. Coefficient alpha and the internal structure of tests. Psychometrika 1951; 16(3): 297-334. doi: 10.1007/BF02310555.
21. Triantaphyllou E, Mann SH. Using the analytic hierarchy process for decision making in engineering applications: some challenges. Inter'l Journal of Industrial Engineering: Applications and Practice 1995; 2(1): 35-44.
22. Ameen RFM, Mourshed M. Urban sustainability assessment framework development: The ranking and weighting of sustainability indicators using analytic hierarchy process. Sustain Cities Soc 2019; 44: 356-66. doi: 10.1016/j.scs.2018.10.020.
23. Romero I, Carnero MC. Environmental assessment in health care organizations. Environ Sci Pollut Res Int 2019; 26(4): 3196-207. doi: 10.1007/s11356-017-1016-9.
24. Askarian M, Khaloii A, Karimi A, Imanieh MH, Razmara h. Assessment of environmental health standards compliance in the University of Medical Sciences hospitals. Armaghane-Danesh 2002; 7(27): 31-8. [In Persian].
25. Lynn MR. Determination and quantification of content validity. Nurs Res 1986; 35(6): 382-5. PMID: 3640358.
26. Ansari M, Ehrampoush MH, Farzadkia M, Ahmadi E. Dynamic assessment of economic and environmental performance index and generation, composition, environmental and human health risks of hospital solid waste in developing countries; A state of the art of review. Environ Int 2019; 132: 105073. doi: 10.1016/j.envint.2019.105073.
27. Şahin T, Ocak S, Top M. Analytic hierarchy process for hospital site selection. Health Policy and Technology 2019; 8(1): 42-50. doi: 10.1016/j.hlpt.2019.02.005.
28. Akhanova G, Nadeem A, Kim JR, Azhar S. A multi-criteria decision-making framework for building sustainability assessment in Kazakhstan. Sustain Cities Soc 2020; 52: 101842. doi: 10.1016/j.scs.2019.101842.
29. Carnero MC. Assessment of environmental sustainability in health care organizations. Sustainability 2015; 7(7): 8270-91. doi: 10.3390/su7078270.
30. Karimi H, Sadeghi-Dastaki M, Javan M. A fully fuzzy best–worst multi attribute decision making method with triangular fuzzy number: A case study of maintenance assessment in the hospitals. Appl Soft Comput 2020; 86: 105882. doi: 10.1016/j.asoc.2019.105882.
31. Zhu L, Zhao Z, Wang Y, Huang Q, Sun Y, Bi D. Weighting of toilet assessment scheme in China implementing analytic hierarchy process. J Environ Manage 2021; 283: 111992. doi: 10.1016/j.jenvman.2021.111992.
32. Malik MM, Abdallah S, Hussain M. Assessing supplier environmental performance: Applying Analytical Hierarchical Process in the United Arab Emirates healthcare chain. Renew Sustain Energy Rev 2016; 55: 1313-21. doi: 10.1016/j.rser.2015.05.004.
33. Handfield R, Walton SV, Sroufe R, Melnyk SA. Applying environmental criteria to supplier assessment: A study in the application of the analytical hierarchy process. Eur J Oper Res 2002; 141(1): 70-87. doi: 10.1016/S0377-2217(01)00261-2.
34. Chan HK, Wang X, Raffoni A. An integrated approach for green design: Life-cycle, fuzzy AHP and environmental management accounting. The British Accounting Review 2014; 46(4): 344-60. doi: 10.1016/j.bar.2014.10.004.
35. Jonidi Jafari A, Golbaz S, Sajjadi H. The study of environmental hygiene indexes status in Karaj Hospitals: 2011. J Hospital 2013; 11(4): 9-18. [In Persian].